GROUP*ARC*—A Collaborative Approach to GIS

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Abstract

Today's Geographic Information System (GIS) includes a multi-user database management system (DBMS) and is embedded in a network environment. The DBMS gives each individual the impression of being the only user—allowing people to work independently but explicitly preventing collaboration with others. An alternative approach is provided by Computer Supported Co-operative Work (CSCW) applications which enable groups of people to collaborate on shared tasks. In this paper we demonstrate the advantages to be gained by developing CSCW GIS applications combining the power of the GIS with the flexibility of CSCW. We present GROUP*ARC* a WYSIWIS (What You See Is What I See) application which enables data from an ARC/INFO GIS to be simultaneously browsed and annotated by multiple participants.

1 Introduction

Geographic Information Systems have become widespread and valuable tools in a variety of government, commercial and academic environments. The importance of sharing information in GIS is well understood.

Like any information system, a GIS is intended to serve the management, planning and decision-support needs of groups of people within an organisation. Collaborative analysis, discussion and decision making will ultimately involve GIS data.

A DBMS is designed to make the actions of concurrent users invisible to each other, giving each individual the impression of being the only user. CSCW, or groupware, enables collaborative work by providing support for 'virtual meetings' where physically separated participants interact as though they are in the same room to discuss and develop shared documents.

GIS applications seem to be particularly likely to benefit from a groupware treatment. Field work, site visits, interaction with similar organisations and communication with a variety of other people—including management, technical staff and information consumers—are typical activities of those who work with GIS. Users are likely to work from a variety of physical locations but remain in the same conceptual workgroups. GIS also relies heavily on pictorial output where a fruitful discussion requires collaborators to be able to point at features, trace routes and generally feel as though they can look over their colleagues' shoulders.

GROUP*ARC* provides facilities such as these, allowing physically separated users concurrently to browse and annotate GIS data in a cooperative way.

The potential for collaborative GIS is beginning to be recognised in other contexts (Karacapilidis *et al.*, 1995, for example).

Two distinct software architectures for implementing CSCW GIS applications are apparent. The interface of individual GIS could be augmented with groupware capabilities. The major disadvantage of this approach is that collaboration between different systems from different vendors would be very difficult to implement. A second approach is to provide groupware as a separate system using a common set of protocols and data formats. Extracting data from each proprietary GIS format would then be essentially the familiar problem of data transfer between GIS systems (Pascoe and Churcher, 1991; Pascoe, 1994).

In this paper we describe GROUP*ARC*, a prototype system we have written using the second approach. GROUP*ARC* represents our attempt to marry the features of GIS and CSCW. The software used is the GroupKit package (Roseman and Greenberg, 1992) developed at the Computer Science department at the University of Calgary described in section 2.1.

The remainder of this paper is structured as follows. In section 2 we review the central concepts of CSCW and indicate their relevance to GIS applications. An outline of GroupKit, a toolkit for developing CSCW applications, is included to indicate the nature of typical CSCWapplications. GROUP*ARC*, the CSCW application we have written for browsing and annotating GIS data is described in section 3. Major design & implementation issues and a description of GROUP*ARC*'s interface and functionality are given in sections 3.1 and 3.2 respectively. An illustration of a possible GROUP*ARC* scenario appears in section 3.3. Some conclusions and suggestions for further work are presented in section 4.

2 Groupware

There are many definitions of the terms CSCW and groupware. For our purposes it is sufficient to regard them as synonymous and we may use the definition

> "computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment"

given by Ellis *et al.* (1991).

Physical meetings can be very inefficient. Delays may occur because participants have other commitments, travel arrangements must be made or meeting rooms/facilities may not be available. The investment of considerable staff time resources in a meeting is not sufficient to guarantee success. The issue may be more complex (or trivial) than was anticipated, relevant information or individuals may not be available and interruptions or diversions may occur.

Partial solutions, such as fax or electronic mail, are available. However, these involve the loss of essential elements such as real-time interaction or gestures.

Groupware aims to provide facilities for virtual meetings. These should mimic real meetings as much as possible. Social conventions such as turn-taking govern the interaction just as they do in face-to-face meetings.

Consider a situation where staff of an organisation are working towards a major decision. A likely scenario is for groups to gather in a meeting. During the course of the meeting each person may make private notes, drift in and out of conversations, or retrieve information from another room. Collaboratively people may scribble comments or circle objects to provide clear and rapid emphasis for shaping the further development of an idea. Software that aims to make a virtual meeting possible for physically separated participants must provide all these facilities and this is the thrust of current efforts in groupware research.

Factors such as the availability of powerful, affordable workstations have led to CSCW becoming a very important area of research (Baecker, 1993). Much of this research has been devoted to studying the human aspects of meetings (Tang, 1991) and to providing tools suited to generic meeting support. GroupKit discussed further in section 2.1, includes tools for voting, ideas processing (brainstorming), text chat, sketching and editing.

However, if groupware is to become truly useful, it must be extended to specific application domains. Our GROUP*ARC* system provides software support for interactions between groups and individuals in the case where GIS data is the primary topic of discussion or development. Our major design goals were to provide an accessible and flexible system.

The individual actions of participants (listing, drawing, gesturing, ...) are intended to achieve a variety of purposes (storing information, expressing ideas, mediating interactions, ...). If they are to be successful, applications such as GROUP*ARC* must avoid constraining the users' freedom of expression.

2.1 A Groupware example

As an example of how software may support the concept of a virtual meeting we briefly describe GroupKit in this section. We have used facilities provided by GroupKit to develop our group aware GIS tool GROUP*ARC*.

GroupKit is a toolkit for developing real-time groupware applications. It was developed in the Computer Science Department of the University of Calgary. See `http://www.cpsc.ucalgary.ca/projects/grouplab/projects/groupkit` for further information.

GroupKit is largely written in the Tool Command Language (Tcl) (Ousterhout, 1994) and its interface is implemented using the Tk widget library. Individual conference applications (or at least their interfaces to GroupKit) are also written in Tcl/Tk.

Tcl is an interpreted language with many attractive features and is ideal for rapid application development. Should performance bottlenecks arise, individual Tcl procedures may be implemented in C or C++ and linked in to the interpreter and, *in extremis*, Tcl interpreters may be embedded in C or C++ programs.

The GroupKit architecture is shown in figure 1. In order to use GroupKit each participant must have access to a machine with the GroupKit software installed. Groups of users who wish to collaborate agree on the address of a well-known (i.e. accessible to all) workstation which will run the *registrar* process. The registrar acts as the central contact point and maintains information about active participants (conference users) and applications (conferences).

Each user runs a *registrar client* which allows users to create, enter and leave conferences. The group will select a registrar client which implements an appropriate conference management policy (e.g. who may start or join particular conferences). One of the registrar clients distributed with GroupKit is visible in figure 2 (the window labelled Open Registration).

Typically, a user will be participating in several conferences attached to the same registrar at a given time. It is generally assumed that an out-of-band audio channel—either via telephone or network audio software—is available.

Individual conference applications are replicated on each participant's workstation. Standard GroupKit conferences include shared editors, ideas processors and sketching tools—some of which are shown in figure 2. Figure 2 shows a snapshot of Clare's screen during a hypothetical discussion with Neville regarding the status of this paper.

The registrar client, visible at the top of the figure, shows that the registrar is currently managing three conferences. Clare has joined each of them and their corresponding windows are also visible in the figure. The Text Chat application has been selected in the conferences list of the registrar client display, resulting in the display of the corresponding list of participants. Further information regarding individual participants is available via the Collaboration menu of each conference application.

The Text Chat conference provides a window containing a pane for each participant and supports simultaneous entry of text. The two other applications shown in figure 2 are an ideas processor—which enables participants to enter ideas into a shared list—and a shared

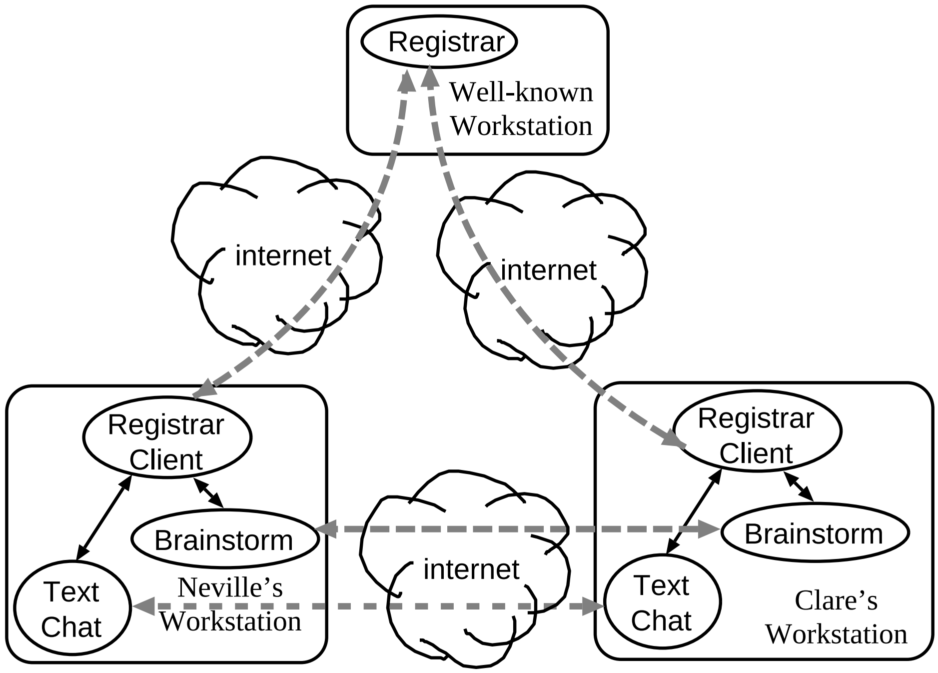

Figure 1: GroupKit architecture

text editor—which enables users to edit independently the same document.

GroupKit enables awareness of other users' actions to be provided in a number of ways. Typically, different colours are used to distinguish individuals. Both the text editor and ideas processor are equipped with multi-user scrollbars consisting of an ordinary scrollbar plus an indicator showing the relative positions of other users. Pressing the mouse button over an indicator (as Clare has done in figure 2) displays information about the corresponding user and allows users to link their displays should one user wish to lead the discussion.

The text editor shown in figure 2 includes another of GroupKit's awareness devices. A *gestalt view* appears in the pane between the file text and the multi-user scrollbar. It is a reduced view of the document which enables many major features to be identified and the locations of other participants are indicated by shaded regions.

We envisage GROUP*ARC* being used in an environment containing similar generic CSCW tools.

3 Group*ARC*: Cscw meets Gis

3.1 Design & Implementation Issues

In this section we outline some of the major design issues that influenced the development of the current GROUP*ARC* system.

Firstly, GROUP*ARC* is not intended as a substitute for a conventional GIS. Each participant in a GROUP*ARC* conference *may* have a GIS available. All that is required to use GROUP*ARC* is for one participant to have access to data in one of the forms that GROUP*ARC* can import. Individual participants are then free to withdraw from the discussions in progress and explore their own ideas in the personal workspace provided by their own GIS. It seems futile to attempt to provide the full range of GIS features in a tool such as GROUP*ARC* whose main function is viewing and annotation rather than data manipulation.

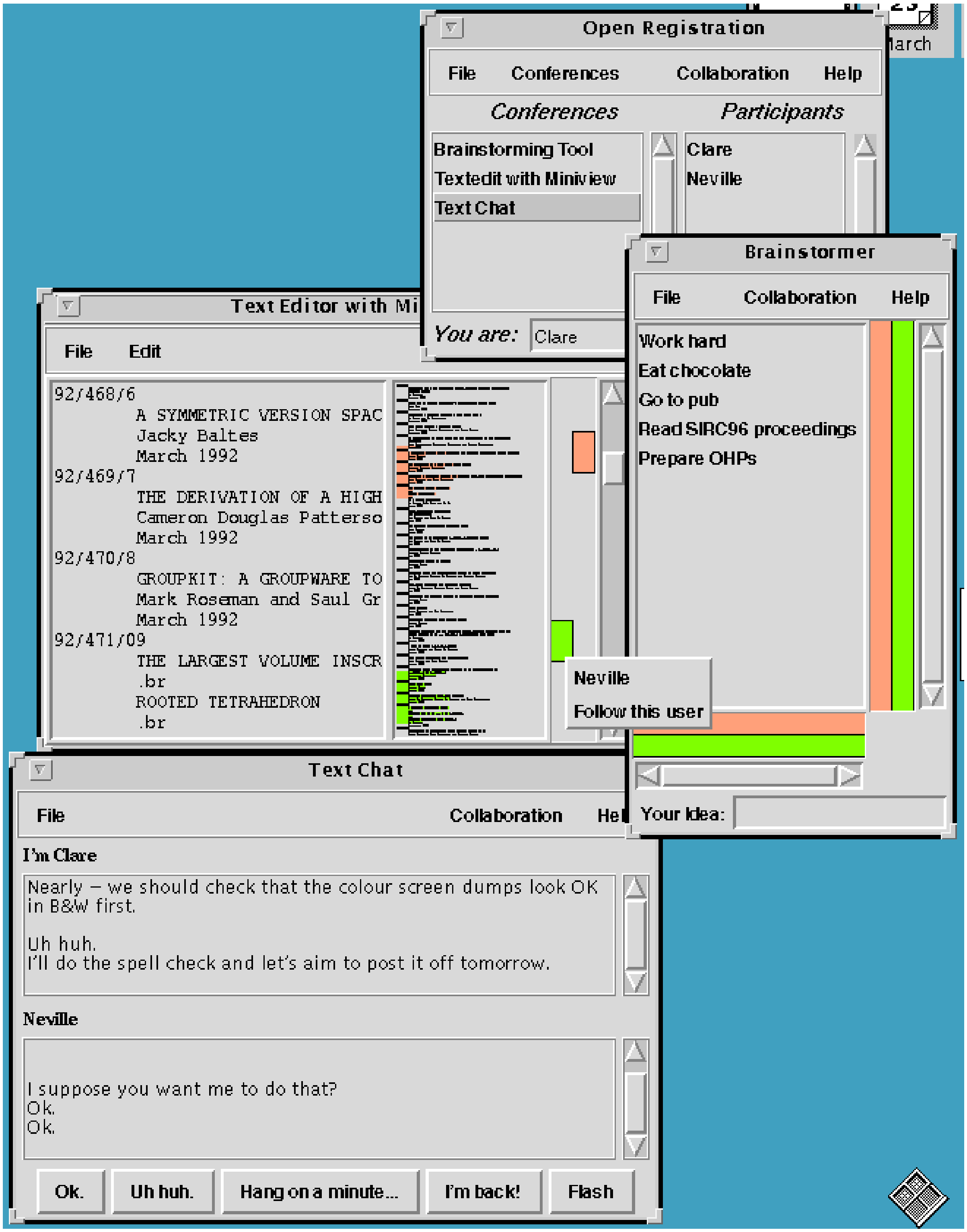

Figure 2: Some typical GroupKit conferences

We assume that the basis for discussions is likely to be one or more thematic layers although is expected that the interaction will focus on a (possibly small) subset of features.

GroupARC is able to read arc and point data exported from Arc/Info using the `ungenerate` command. The data for each arc consists of an arc ID followed by a list of x,y coordinates and for points a list of pointIDs with their respective coordinates. Further details of the Arc/Info formats involved are available (Hickin *et al.*, 1991, for example).

Attributes associated with these features can be read from the text versions of the corresponding Arc/Info arc and point attribute tables. Thus GroupARC can display information derived from the topology, such as areas and perimeters, without re-calculation.

Accessibility is encouraged by independence of vendor-specific Gis products. We have chosen to use the Arc/Info Gis but, in fact, only one of the authors (C.D.C.) has Arc/Info available on-site. All that is required to provide coverages for GroupARC is the ability to translate data into Ascii text files of a specified format. General solutions to this problem are available (Pascoe, 1994). Apart from GroupARC itself, the Tcl/Tk software and an internet connection there are no other requirements for participation in GroupARC conferences.

Only minimal training (typically only a few minutes) is required in order to use the system. The number of different user options has deliberately been kept small. While it is tempting (distressingly so for one of the authors) to provide many features of a full-blown Gis, we believe it important to focus strongly on supporting GroupARC's browsing and interaction support rôles.

Performance is satisfactory, even though Tcl is interpreted. This is largely because GroupARC does not have to provide computationally expensive Dbms services such as concurrency control.

3.2 Group*ARC* interface

Figures 3 and 4 illustrate part of a typical (but imaginary!) GroupARC session.

Colour is used extensively in GroupARC. Each participant has a characteristic colour. In the conference illustrated Clare is pink and Neville is chartreuse. The multi user scrollbars show which part of the document each participant is currently viewing.

Colour is also used to distinguish coverages. Existing coverages fade slightly when a new coverage is loaded. The most recently loaded coverage will have the darkest colour unless the user explicitly selects a new "top" coverage.

The GroupARC equivalent of pointing or tracing with a finger is the highlighting of particular features in appropriate colours. If desired, users can enable such features to simplify discussions by selecting from a range of policies.

The GroupARC interface contains a number of elements:

- The menu bar at the top of the display contains, in addition to the standard GroupKit menus, two menus specific to GroupARC.

  The Coverages menu allows each user to stack the coverage layers in an appropriate order. This feature is particularly useful where features overlap directly—as do roads and sewers in this example.

  The Policy menu allows users to control the level of awareness of their actions available to other participants. For example, a user may wish to make some rough sketches in private while developing an idea before sharing it with the group.

- Below the menu bar is a pane which displays three pieces of information.

  - Cursor position in Gis co-ordinates is indicated by the x & y values appearing at the left.
  - When the cursor is above a feature, the name of the corresponding cover-

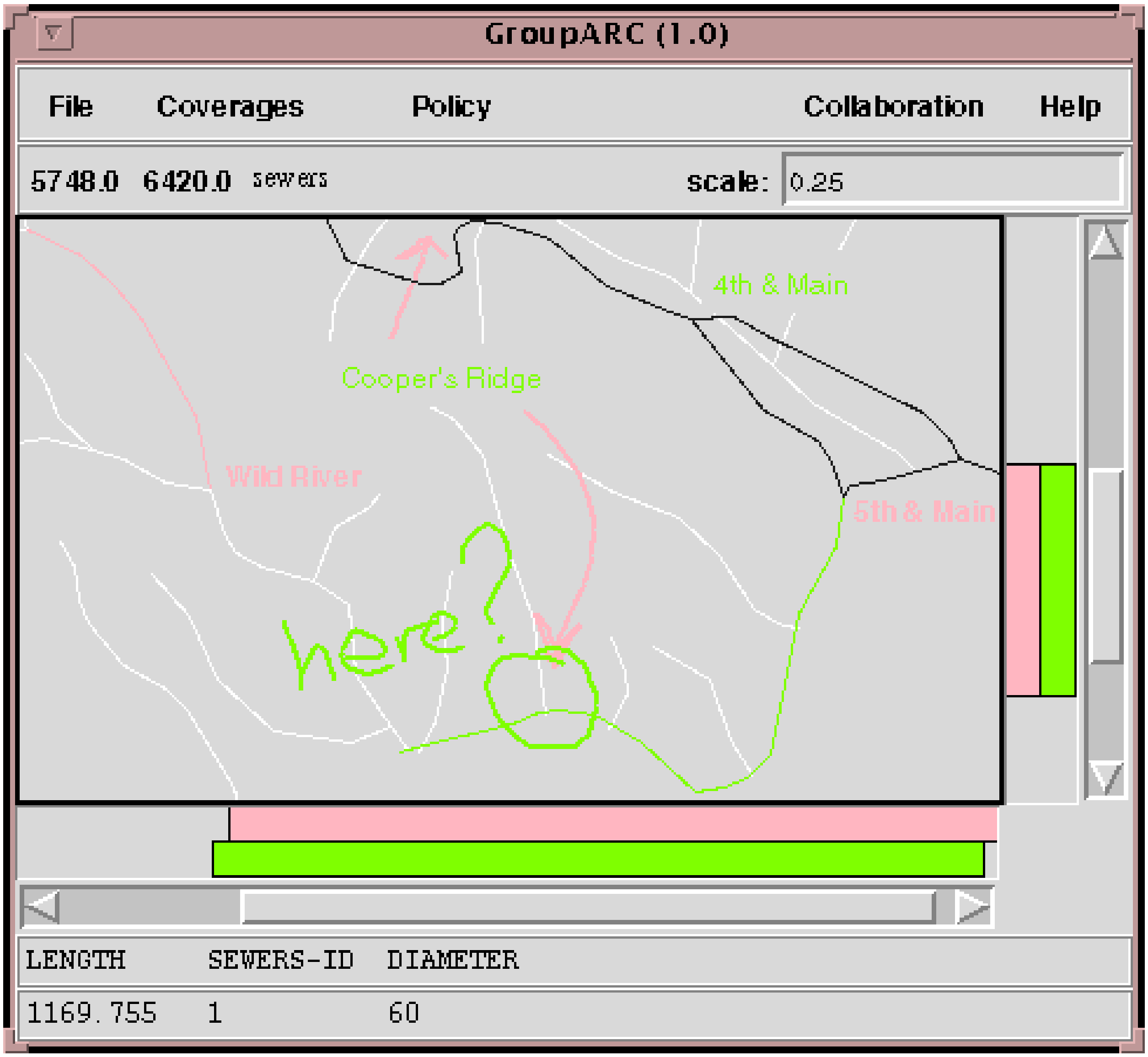

Figure 3: Flood management discussion—Neville's view

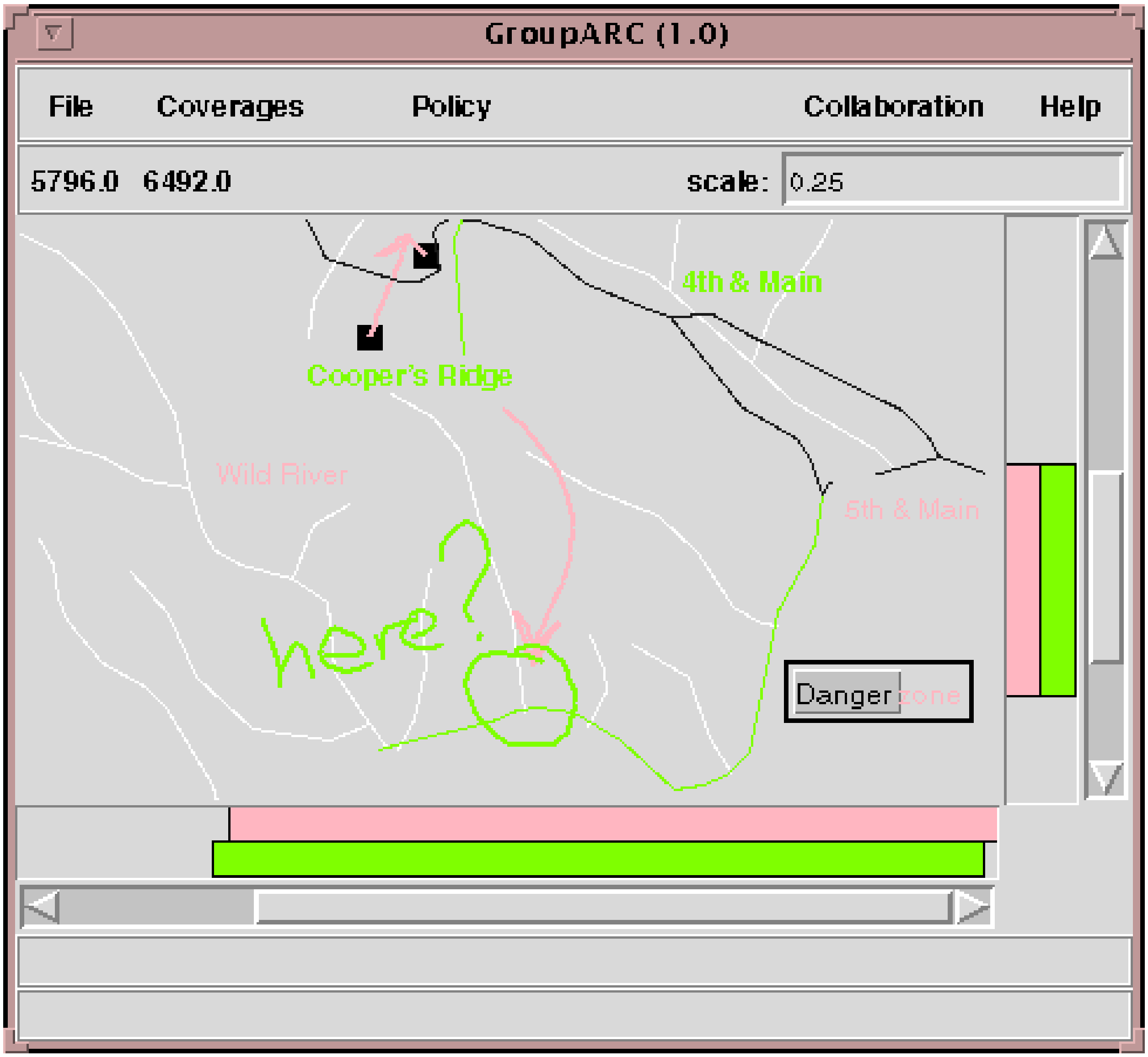

Figure 4: Flood management discussion—Clare's view

age appears to the right of the cursor co-ordinates.

  - The current scale factor appears in the entry at the right. Users may change the scale at any time, zooming in to examine particular features in detail or zooming out to study the wider context.

- The two panes at the bottom of the display show attribute metadata and data corresponding to the feature currently under the user's cursor. In figure 3 Neville's cursor is over an arc representing a piece of sewer pipe. In the case of overlapping features at the cursor position, the feature from the uppermost coverage is chosen. This feature appears highlighted in the user's chosen colour. Depending on the current policy options, other features may also appear highlighted in the chosen colours of other participants. These would be those features currently under the cursors of the other participants.

- Multi-user scrollbars (described in section 2.1) border the main pane, indicating the relative positions of all conference participants.

- The main pane itself displays the available coverages, each in a different colour. The stacking order of coverages may be changed via the Coverages menu and individual coverages may be identified readily by simply moving the cursor over particular features.

- Conference participants may add *annotations* in order to aid their discussions by storing information or expressing ideas. These may be free-form sketches—such as the circles and arrows in figures 3 and 4—or text—such as the intersection labels in figures 3 and 4. Annotations appear in the chosen colour of their creator.

3.3 Using Group*ARC*

The topic of the discussion is potential flood danger. Two coverages—streams and sewers—have been loaded. The darker arcs in figures 3 and 4 belong to the sewers coverage. Annotations have been added as the discussion progressed. Text annotations have been used for reference points—major intersections, a flood-prone river and a major watershed.

Free-form annotations have been used to support *gestures*—arrows indicating the direction of floodwaters towards populated regions and circles to indicate areas where sandbagging crews should be deployed.

A real-time discussion of a map among a group of people usually involves much pointing, gesticulating and annotating. A CSCW application such as GROUP*ARC* allows this to happen in real-time in contrast to the delays introduced by a fax or email exchange.

Discussions also involve individuals behaving in a variety of ways. For example, they must be free to focus on different portions of the map or withdraw from active participation and examine other data as they formulate ideas in private. The discussion may take the form of a lively debate, with much concurrent annotation and gesturing, scrolling around and scribbling out of previous contributions. At other times the participants may observe passively while one person demonstrates a possible solution.

GroupArc manage these facilities in a number of ways. Awareness of others is provided by the multi-user scrollbars (which indicate the extent of overlaps between individual views), feature highlighting and annotations tagged by their contributors colour. Heated debate may be indicated by coincident views and concurrent annotations. Re-scaling of the canvas may also allow hot-spots of activity to be identified.

GROUP*ARC* users have the ability to disable the propagation of feature highlighting to other participants.

4 Conclusions

Our GroupARC application successfully combines aspects of GIS and CSCW software to provide facilities for browsing and annotating spatial data. Conference participants may be located anywhere on the internet and may take a range of rôles ranging from observer to discussion leader during the course of a session. Collaboration is aided by awareness mechanisms such as multi-user scroll bars and highlighting of individuals locations. Annotations not only aid discussions in progress but also provide a record of the session when the final view is saved or printed.

We have demonstrated that a lightweight and portable application may be implemented in Tcl/Tk using the GroupKit toolkit to run on a range of common and affordable platforms. The addition of facilities to read files created by other GIS will increase the potential user base.

We believe that CSCW GIS systems are not only feasible but will have much to offer the GIS community over the next few years.

Future work on GroupARC will explore a number of issues in greater depth. Educational applications of GroupARC seem promising. In particular, GroupARC can provide a low cost means of enhancing the accessibility of data from a GIS—often a scarce resource or requiring a greater than average system configuration.

We are particularly interested in investigating the policies available to GroupARC users. Some very subtle situations can arise when the full implications of choices are explored. Possibilities range from a complete free-for-all (the *broadcast* policy in GroupARC) to completely private workspaces with a conventional lock-based concurrency control mechanism for modifying the shared document.

Maps (and their GIS counterparts) are visually complex artifacts. The difficulties posed for GIS by information overload have been recognised (Churcher, 1995). Awareness is also recognised as a major issue for CSCW applications (Tang, 1991; Greenberg *et al.*, 1996). Devices such as multi-user scrollbars, gestalt views and fisheye views (Sarkar and Brown, 1994) can help. Our technique for displaying attribute values of geographic features is loosely based on some of the ideas of general semantic filters (Fishkin and Stone, 1995; Stone *et al.*, 1994). There is considerable scope for incorporating user-configurable forms of such facilities into GroupARC and we intend to experiment with suitable metaphors for browsing spatial data.

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